Recent Technology Progress in Undergrounding

ARPA-E Workshop

Ben Lanz

Chairman of the Board
Power Delivery Intelligence Initiative (PDi²)

blanz@pdi2.org

PDi2.org

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Power Delivery Intelligence Initiative (PDi²)

- PDi² uses data to evaluate OH vs. UG power infrastructure investments:
  - Life-Cycle Costs
  - Total Cost of Ownership
  - Improving Grid Resiliency
- Educate Stakeholders

Why Some Say No to UG?

- Higher upfront cost
- Can’t find faults
- Longer duration faults
- Flooding and water problems
- Lower capacity for long dis.

Why Others Say Yes to UG?

- Reliability
- Resiliency
- Capital Investment
- Stable rate base growth
- O&M improvement
- Safety improvement
- Lower life-cycle cost
- Real estate value improvement

“steel (or cable) in the ground”

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Why Now?

- Electrification demands higher reliability
- More people living/working in high-risk areas
- Vital to economy/jobs/GDP
- Customers want a safer grid
- Customers willing to pay for it
- Utilities need long term rate base
- Regulators want equitable investments & stable rate growth
- Advances in technology driving costs down

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"Electricity is becoming as vital as food & water"

Recent Technology Advancements

- Material Science
- Design
- Construction technology
- Operations & Maintenance

INTELLIGENT UNDERGROUNDING

21st-Century Costs of Underground Distribution

The cost of underground electric distribution is coming down.

By **MIKE BEEHLER**, Mike Beehler & Associates

Advancements in material science, construction methods and emerging technologies make 21st century costs for undergrounding T&D assets much more attractive for planners and engineers than ever before. The old "rules of thumb" about the higher costs of T&D underground are no longer valid. The costs are now coming down.

Innovation and continuous improvement programs have positively impacted underground costs in the areas of design, construction, operations and maintenance of new and existing feeders, underground residential distribution (URD) and service connections. The state-of-the-art experience and science of modern cable systems around the world suggest properly installed and operated underground cable systems can safely and reliably serve customers significantly longer than overhead line components. In addition, data is starting to show dramatically lower operation and maintenance expenses over the life of underground assets.

These results trend toward the achievement of net-positive life-cycle value for underground with dramatically better resiliency. Utilities are evaluating these intriguing concepts and the current tangible costs while considering the harder-to-quantify benefits of safety, reliability and aesthetics on behalf of their customers in diverse service territories.

Material Science And Cable Design

Advancements in material science have changed many parts of the electric distribution system and the industry. Utilities are closely monitoring these advancements. Significantly longer cable life can be achieved using innovative semiconducting and insulating materials. Semiconducting shield materials with smoother surfaces reduce stress enhancements and semiconducting jackets provide continuous grounding to dissipate overvoltage conditions more quickly. Enhanced insulation materials have demonstrated significantly longer life under accelerated wet-aging conditions.

"These enhancements contribute to underground cables that now are projected to last longer than the traditional overhead line," said Brent Richardson, senior end-use marketing manager for Dow and an executive board member of the Power Delivery Intelligence Initiative (PDi²).

For example, a recent review of state-of-the-art cable science by Chatteron et al. at the Fall 2019 IEEE Power & Energy Society's Insulated Conductor Committee meeting summarized that cables can last well beyond 100 years, which far surpasses the average 50-year wood pole life quoted by the North American Wood Pole Council.

"Stronger cable designs on larger reels cut civil design and construction costs by reducing the number of manholes needed, traffic control and public disruption, the number of splices and terminations, and cable handling costs," noted Matt Raymond, division manager of Haugland Energy and a PDi² associate member.

Old accessory designs relied heavily on field preparation of joint and termination primary insulation that could not be routinely pretested. Now, components use controlled molded stress control and can be 100% factory tested. These designs also have various features that reduce installation time and the rigor of work in varied

Today's outdoor terminations are factory produced and tested. Source: Ivan Jovanovic, director of engineering specialty products with G&W Electric and associate member of PDi2.

36 T&D World | March 2021

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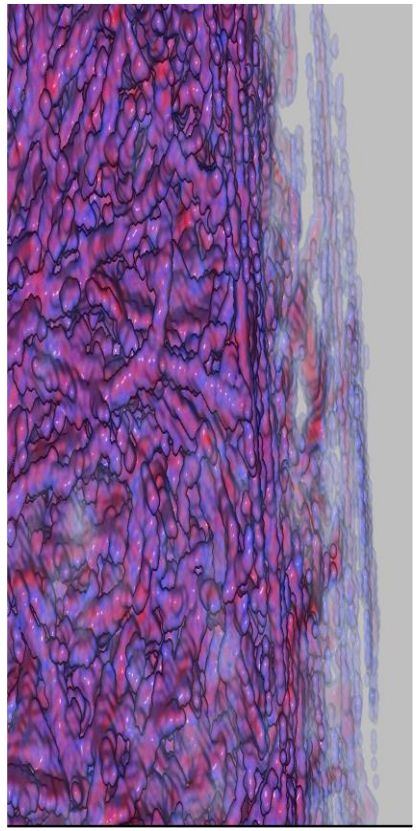
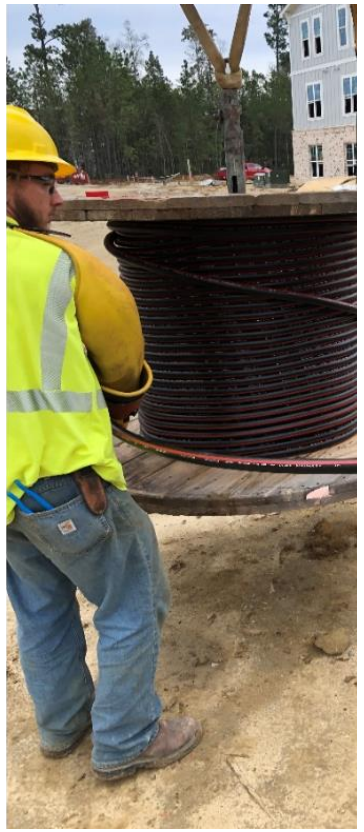
Material Science

- 100-year+ cable life
- Fully submersible & directly buried
- Stronger cable on bigger reels
- Factory built & tested accessories
- HV & MV DC for long distance





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Design

- 3D Distribution standards
- 3D GIS mapping
- Integrated capacity analysis for DER’s
- Micro-grid critical feed(s) and loads

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Construction Technology

- Precast manholes & duct banks
- Robotics & Trenchless tech.
- Plasma tunnelling
- Meter adapter boxes
- Factory comparable QC test
- Augmented reality

Commissioning Spec.	Miles	Fails/100 mi/yr
Pwr. Freq. PD Test (MV)	4,440	0.01
No Commissioning (MV)	13,170	2.0

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Operations & Maintenance

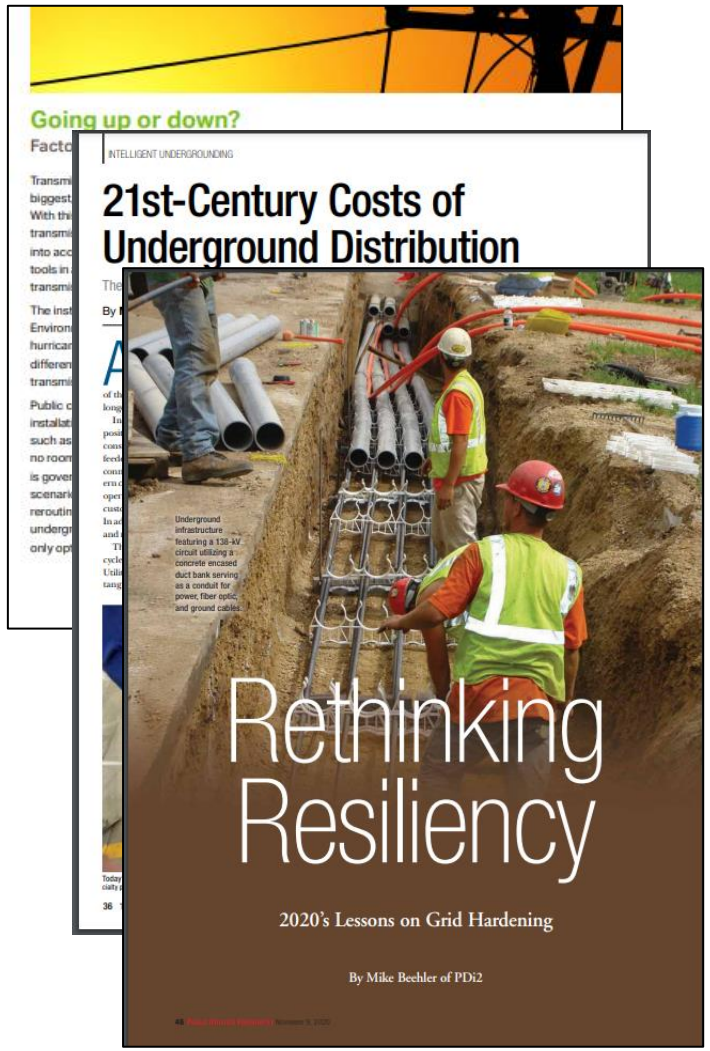
- Advanced qualification training/testing
- Operations best practices
- Event detecting line sensing
- AI Predictive condition assessment

Recent Technology Advancements Address Utility Concerns

1. Higher upfront cost
2. Can’t find faults
3. Longer duration faults
4. Flooding and water problems
5. Lower capacity for long dis.

1. Better life-cycle models, construction technology & efficiency improvement
2. Commissioning, training certification & fault location technology
3. Online line sensing
4. Manufacturing and material science
5. HV and MV DC lines

PDi2.Org Complimentary Educational Resources



- Papers & Articles
- Live & Recorded Webinars
- Research
- Videos interviews with industry leaders
- Sponsored utility panel sessions

T&DWorld 21st-Century Costs of Underground
A 12-part webinar series

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October 2019
Utility Resiliency Playbook
Developed by PDi²

UTILITY INFRASTRUCTURE RESILIENCY PLAYBOOK

VIEW RESOURCE

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Case Study Back up Slides

Where Has Undergrounding Started?

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WEC Energy
Strategic Undergrounding Program

- Customer survey: Vast majority willing to pay more for underground
- Targeting 2,200 miles
- $4.30/month (5%) increase
- 97% reduction in customer minutes
- Targeting 60-year life

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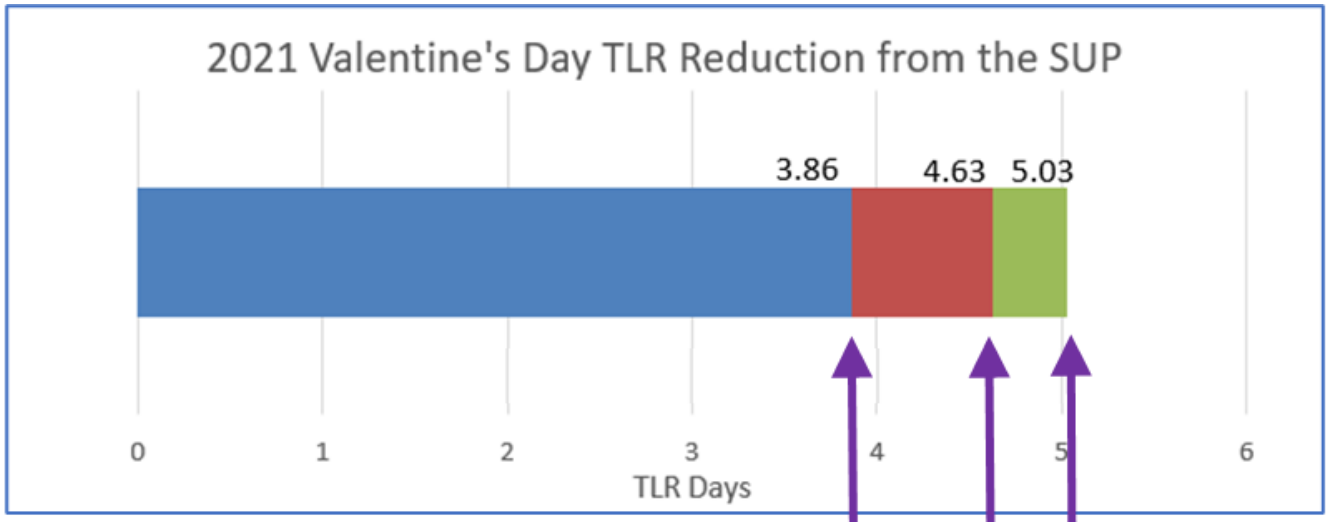
Dominion Energy SUP Case Study

- 4,000 mile strategic undergrounding program (SUP)
- Goal, 50% Total Line Restoration (TLR)
- TLR Metric Application



TLR if All SUP was Completed

Actual TLR

TLR with No SUP Program

TLR=Total Length of Restoration

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FPL Strategic Undergrounding Program

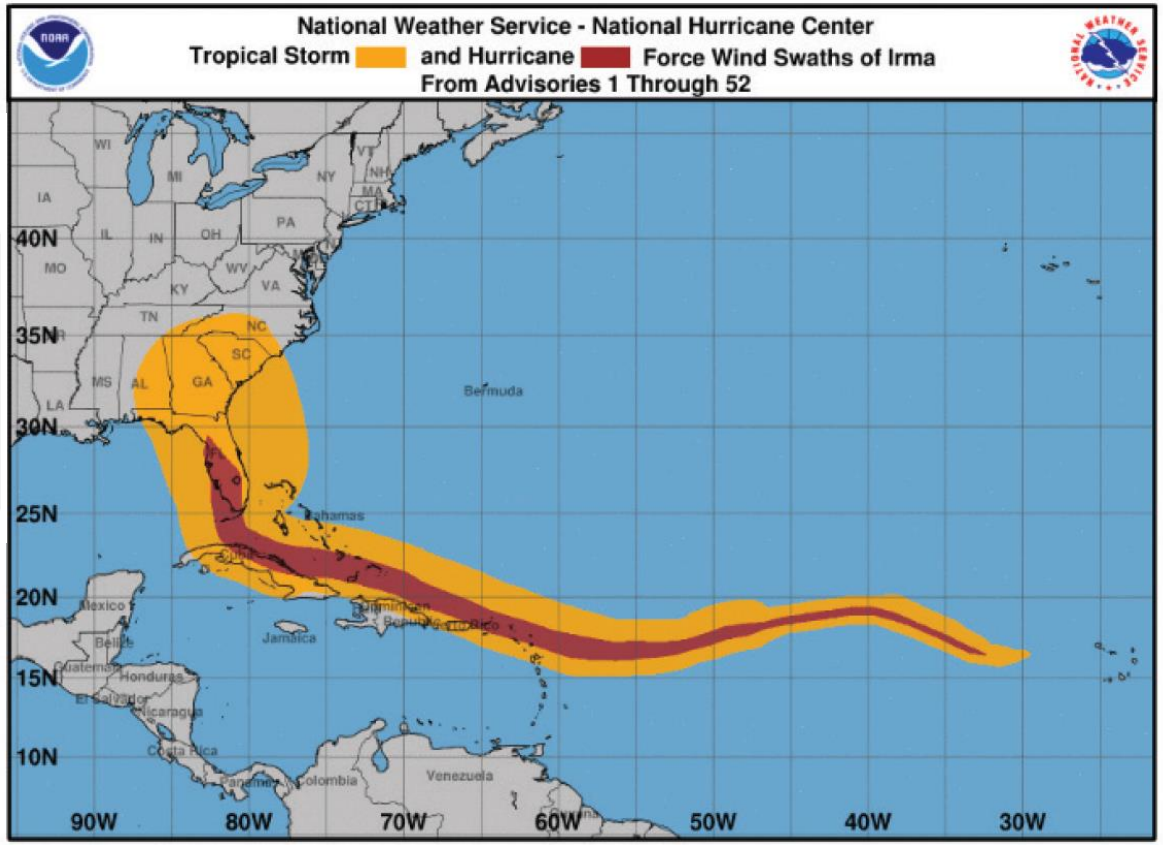
- State GDP $3.3 Billion/day
- 20 year/20 Billion program

Undergrounding Pilot Results

FPL Outage Rates for Facilities Impacted by Hurricane Irma

	Transmissions	Distribution feeders	Distribution Laterals
Overhead, Non-hardened	20%	82%	24%
Overhead, Hardened	16%	69%	N/A
Underground	---[7]	18%	4%

Hurricane Irma – Tropical Storm and Hurricane Force Winds



Source: NOAA's National Hurricane Center

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